

MUNICIPAL FLEET COSTS AND ENVIRONMENTAL IMPACTS CALCULATOR

OVERVIEW

The USAID South Africa Low Emissions Development (SA-LED) Program developed an Excel-based [Municipal Fleets and Environmental Impacts Calculator](#)¹ to support South African metropolitans and municipalities in estimating the costs, and greenhouse gas (GHG) and air pollution emissions of fossil fuel and alternative bus fleets, including the following fuel types:

- Diesel
- Natural gas
- Biogas
- Electric
- Biodiesel

Users of the calculator can customize fuel sources and prices, electricity mixes, discount rates, and other bus fleet variables to better understand how these factors can influence overall fleet costs and impacts. The tool also includes life-cycle components (i.e., supply chain components) for both GHG emissions and costs.

BENEFITS FOR USERS

SA-LED developed the calculator with the goal of helping municipalities to better understand the costs and benefits, both economically and environmentally, of different bus fleet alternatives. The flexibility of the tool allows for quick or highly detailed assessments depending on the needs of the user. Specifically, the calculator was modeled with intended benefits of:

- **Supporting decision making:** users can compare and contrast fossil and alternative fuel bus costs and environmental impacts for new fleets.

¹ <https://www.climatelinks.org/resources/municipal-fleets-and-environmental-impacts-calculator>

- **Modeling full life-cycle costs:** alternative fuel fleets can have significant fuel consumption cost savings over fossil fuel fleets, and modeling life-cycle costs can show savings over time despite higher capital costs in bus purchasing. For example, electric buses have much higher fuel economy rating leading to significant fuel cost savings, and renewable natural gas can often be sourced from low-cost options (e.g., local landfill gas).
- **Complete customization:** user inputs and code for the Excel-based calculator are completely unlocked, meaning that users can vary any part of the calculator’s assumptions and inputs to match specific project needs.

CALCULATOR COMPONENTS

User Inputs

The calculator first walks the users through a series of inputs that drive the calculations. Tool users can use the national default values for each input already displayed in the calculator, or users can input custom values. Different user inputs can influence both costs and environmental impacts, and Table 1 shows a complete list of inputs and the affiliated outputs.

User Input	Affected Output
Analysis period	Costs & Environmental Impacts
Bus purchase schedule	Costs & Environmental Impacts
Bus type	Costs & Environmental Impacts
Bus use (vehicle km traveled)	Costs & Environmental Impacts
Carbon tax	Costs
Discount rate	Costs
Electricity mix	Environmental Impacts
Fuel price	Costs
Fuel source	Environmental Impacts
Projected electricity GHG intensity	Environmental Impacts

Table 1. User inputs and the related outputs. Environmental impacts include GHG and air pollution emissions.

User inputs are grouped into the following groups:

- **Municipality and Project Details** – use these inputs to customize project specifics to a local area and transit agency
- **Bus Use** – the inputs allow the user to customize fuel consumption (bus use, fuel economy), fuel types, and fuel price
- **Cost Estimation** – the two inputs in this category control how capital and operational costs increase over time (discount rate), and how GHG emissions are valued (carbon tax)
- **Fuel Production and Other Assumptions** – these inputs primarily control GHG emissions and air pollution emissions through fuel sources and pathways, electricity grid mix, global

warming potential factors, and an option to project a decline in GHG intensity of electricity over time

- **Bus Purchase Schedule** – these inputs allow the user to customize a bus purchase schedule over a 10-year period

Calculations

Based on the user inputs, a series of related calculations generates the calculator's final outputs. Figure 1 shows how the user inputs and assumptions flow into these different calculations. Each box within Figure 1 represents a different tab in the Excel file. The **dark green** tab holds user inputs, the **light green** tabs hold calculations, the **orange** boxes tabs hold cost assumptions, the **blue** tabs hold emissions assumptions, and the **yellow** tab holds tool outputs.

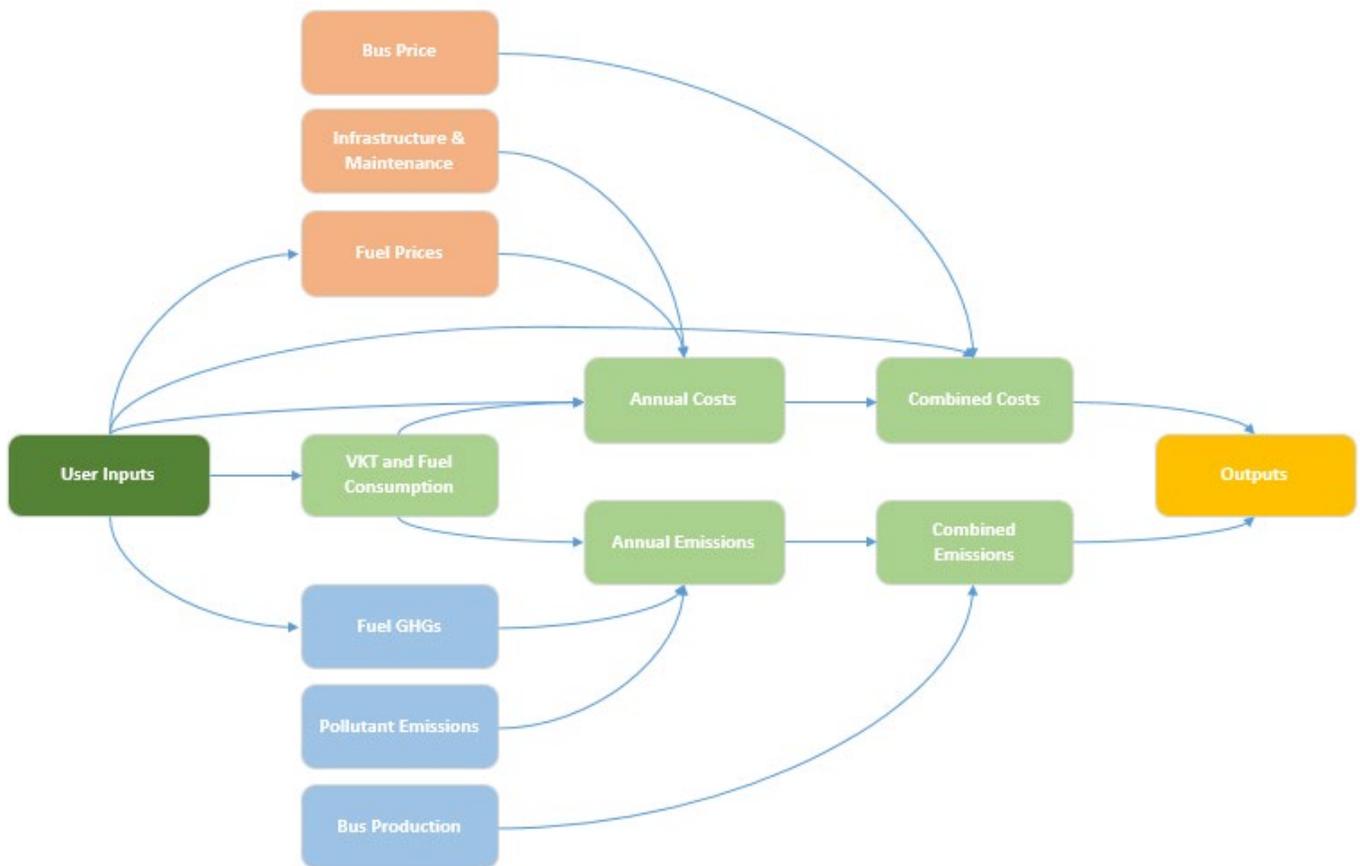


Figure 1. Summary of flow of calculations and tabs within Excel file.

The user can examine these specific calculations at any time. All assumptions and data points are documented within each tab and can be changed by the user to fully customize the calculator to project needs.

Outputs

After filling out the “User Inputs” tab, the user can view the “Outputs” tab to obtain both graphical and detailed costs and environmental impacts of the project. The “Outputs” tab begins by showing the general project details and bus purchase schedule, and then goes into detailed results for costs and environmental impacts, both of which are described in the following sections.

Outputs – Life-Cycle Costs

The life-cycle cost outputs separately summarize multiple elements of total project costs: net present value (NPV), annual costs, and capital costs. Figure 2 shows the graphical display of an example NPV, which is broken out into seven different distinct cost categories.

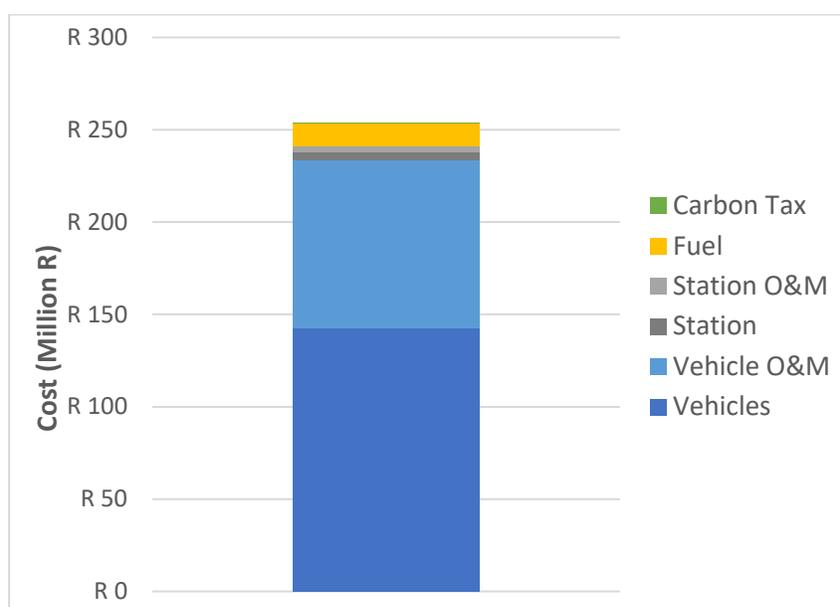


Figure 2. Example NPV summary broken out by different life-cycle cost contributions.

Costs categories in the results summary include:

- *Carbon tax* – This includes costs associated with South Africa’s national carbon tax.² These costs assume a starting point of R30/tonne CO₂e in 2019 and uses the user-defined or default discount rate to increase the tax rate annually until 2022 where it is capped.
- *Fuel consumption* – This category includes costs associated with vehicle fleet fuel consumption. Projected default diesel and electricity costs are specific to South Africa, while natural gas is based on projected European prices. Biodiesel and biogas use a user-defined or default marginal cost increase over diesel (for biodiesel) and natural gas (biogas).
- *Station construction, operations and maintenance* – The calculator development team assumed that any buses purchased as part of the analysis would require station construction for bus refueling

² National Treasury, Republic of South Africa. 2017. Explanatory Memorandum for the Carbon Tax Bill. Available at: <http://www.treasury.gov.za/public%20comments/CarbonTaxBill2017/Annexure%201%20Explanatory%20Memorandum%20Draft%20Carbon%20Tax%20Bill%20December%202017.pdf>

and general maintenance. The team also assumed that only one station was required for each bus type regardless of the number of buses, meaning that construction costs are never counted more than once for a given bus type. This cost category reflects the construction capital costs (“Station” in Figure 2) and ongoing operation and maintenance costs (“Station O&M”).

- *Vehicle purchasing, operations and maintenance* – Similar to station costs, vehicles include both purchasing capital costs (“Vehicles”) and ongoing operation and maintenances (“Vehicle O&M”). The calculator estimates operation and maintenance costs based on the distance traveled by buses, and estimates purchasing costs based on the bus purchase schedule inputs.

The cost outputs also give detailed table displays for NPV, annual costs, and capital costs. The annual costs show fuel costs, operation and maintenance for stations and vehicles, and carbon tax costs. Table 2 displays an example of these annual costs for a five year period. The calculator also details vehicle and refueling station capital costs for each year of the analysis period, which reflects purchases based on the bus purchase schedule defined by the user.

Cost Element	2018	2019	2020	2021	2022
Fuel Costs	R1,463,093	R1,438,555	R1,475,426	R1,513,516	R2,075,804
Station O+M	R403,629	R436,726	R472,538	R511,286	R553,211
Vehicle O+M	R7,069,929	R7,649,663	R8,276,936	R8,955,645	R16,066,215
Carbon Tax	R0	R16,310	R17,177	R18,077	R25,781

Table 2. Example annual costs from the calculator outputs for a five year period.

Outputs – Lifecycle GHG Emissions

The calculator development team used life-cycle assessment (LCA) methodologies to generate GHG emission estimates for vehicle fleets. Figure 3 shows an example summary output from the calculator broken out by three main life-cycle stages.

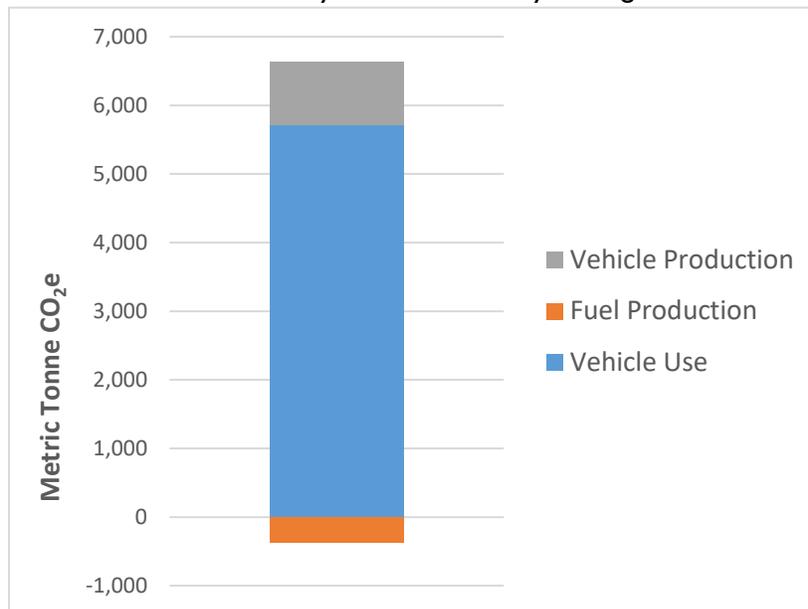


Figure 3. Example calculator results life-cycle GHG emissions.

The calculator’s life-cycle stages for GHG emissions include:

- *Vehicle production* – this includes the supply chain GHG emissions associated with manufacturing of new buses. Electric bus production emissions include both new bus manufacturing and lithium-ion battery production.
- *Fuel production* – fuel GHG emissions in this category account for “well to pump” supply chain activities, which includes all emissions before of vehicle use (i.e., fuel extraction, refining, shipping).
- *Vehicle use* – this category includes emissions from fuel combustion during vehicle use.

Table 3 shows an example of detailed emissions on the “Outputs” tab. In the “Annual Emissions” and “Combined Emissions” tabs of the calculator, users can find a specific details for GHG emissions characterized through vehicle use emissions by fuel type and year, fuel production emissions by year, and vehicle production emissions by year. The supporting emission factors for the modeling can be found in the “Fuel GHGs” and “Bus Production” tabs.

Source	Total Project Metric Tonne CO ₂ e	Annual Metric Tonne CO ₂ e/yr
Vehicle Use	5,722.4	572.2
Fuel Production	-379.1	-37.9
Vehicle Production	916.7	91.7
Total	6,260.1	626.0

Table 3. Example table outputs for life-cycle GHG emissions.

Outputs – Air Pollutant Emissions

The calculator’s air pollutant emission modeling provides results for six different pollutants: volatile organic compounds (VOCs), carbon monoxide (CO), nitrogen oxides (NO_x), two particulate matter size categories (PM₁₀, PM_{2.5}), and sulfur oxides (SO_x). Figure 4 shows the graphical output from the calculator for air pollutant emissions.

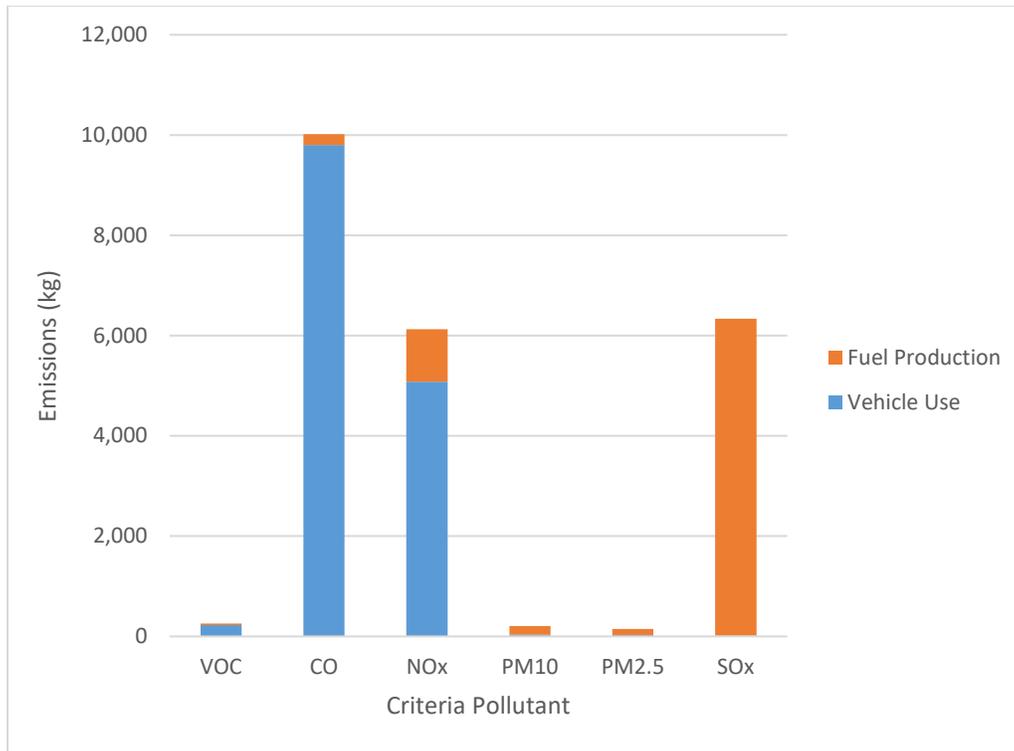


Figure 4. Example results for air pollutant emissions.

The air pollutant emission categories share two of the same categories as the GHG emission categories. However, air pollutant emissions only reflect fuel combustion, and do not include any supply chain or life-cycle emissions that are included in the GHG emission assessment. For vehicle use, the air pollutant emissions reflect any emissions that result from combustion of fuel while operating the buses. For fuel production, the air pollutant emissions only include fuel combusted for electricity generation, and do not include the supply chain emissions (i.e., well to pump emissions) that are included in the GHG emission assessment of fuel production

Table 4 shows example detailed results from the calculator’s “Outputs” for both total project and annual emissions by pollutant.

Source	Total Project (kg)						Annual (kg/yr)					
	VOC	CO	NOx	PM10	PM2.5	SOx	VOC	CO	NOx	PM10	PM2.5	SOx
Vehicle Use	227.1	9,804.5	5,078.0	34.4	30.0	16.1	22.7	980.5	507.8	3.4	3.0	1.6
Fuel Production	28.3	214.6	1,050.3	168.6	119.5	6,319.6	2.8	21.5	105.0	16.9	11.9	632.0
Total	255.4	10,019.1	6,128.2	203.0	149.4	6,335.7	25.5	1,001.9	612.8	20.3	14.9	633.6

Table 4. Example air pollutant emission results from the “Outputs” tab.